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ABSTRACT

This study investigated the static balance performance of 20 nonhandicapped and 20 learning disabled male children in Texas by comparing mean distances of center of pressure displacement as measured by a forceplate. Specifically, mean displacements in the medial-lateral plane during five static balance tests were measured from a neutral starting position. Hypotheses of no significant difference between the scores of the two groups were tested for overall balance performance (equal mean vectors) and differences between group means. This report describes the testing instruments used and the test methodology and then illustrates the test positions for the five static balance tests. Descriptive statistical data obtained from the tests were computed on the subject group means on the score determination of static balance performance and time-in-balance. Each of the hypotheses of no significant difference in static balance performance between the nonhandicapped and learning disabled subject groups was accepted. (JD)

Kinetic Comparison of Static Balance Performance of Nonhandicapped and Learning Disabled Male Children

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Static balance, or the ability to maintain a state of equilibrium, is an important facet of children's neurological development and is a foundation for motor control. Measurement of static balance performance is included in a number of assessment instruments used by physical educators (Arnheim & Sinclair, 1979; Brigance, 1978; Bruininks, 1978; Cratty, 1966; Feris et al., 1983; Sloan, 1956). Results obtained from such field measures of static balance are limited to time-in-balance in the test position, behavioral observations and descriptions of performance, and standard scores when standardized tests are utilized.

The essence of static equilibrium is based on the biomechanical concept that the sum of the moments, or torques, is equal to zero (Hinson, 1981). This concept supports the probability that static equilibrium is dynamic in nature and involves movement over a stationary base of support (Hellebrandt, 1938).

Using a forceplate to measure fluctuation of the vertical ground reaction forces involved in maintaining equilibrium would appear to provide a more unbiased and quantitative description of static balance performance than would temporal and behavioral observations. It has

been questioned whether temporal measurements reflect the underlying processes of static balance performance (Effgen, 1981). If the amount of postural sway is a reflection of neurological maturity, then postural sway needs to be measured.

Reports in the research literature are conflicting in regard to balance performance of learning disabled children when compared to nonhandicapped contrast groups. Some investigators reported that nonhandicapped subjects perform better than learning disabled subjects in balance tasks (Bruininks & Bruininks, 1977; Cinelli & DePaepe, 1984; Orfitelli, 1977), whereas other investigators reported no significant differences between the two groups (Kendrick & Hanten, 1980; Morerod, 1982; Schneider, 1981).

The purpose of this study was to investigate static balance performance of nonhandicapped and learning disabled male children by comparing mean distances of center of pressure displacement as measured by a forceplate. Specifically, mean displacements in the medial-lateral plane during five static balance tests were measured from a neutral starting position. Hypotheses of no significant difference between the scores of the two groups were tested for overall balance performance (equal

mean vectors) and differences between group means with the following tests: (a) Standing on Preferred Leg on Balance Beam test, (b) Standing on Preferred Leg on Balance Beam--Eyes Closed test, (c) Standing on One Foot test, (d) Standing Heel to Toe with Eyes Closed test, and (e) Standing on One Foot with Eyes Closed test. The test positions for the five static balance tests are depicted in Figures 1 through 5.

Subjects

Subjects were nonhandicapped (n = 20) and learning disabled (n = 20) male children between the ages of 8 and 11 years from northern Texas. Both groups were equivalent with respect to age. No subjects displayed any known orthoptic vision problems or physical impairments. The nonhandicapped subjects were receiving no special education services, whereas the learning disabled subjects were receiving special education services.

Instrumentation

The Cover Test (Pyfer & Johnson, 1981), a biopter (Stereo Optical Co., Inc.) and a modified M-125 Titmus Biopter Vision test (Vodnoy, 1970) were used for depth perception screening. Five far point vision tests were used to examine vertical and lateral phorias, central

fusion, and stereopsis.

The forceplate used in the study was a triaxial, quartz transducer measuring 60 by 40 cm (Kistler Instrument Corp.). The active area on top of the forceplate measured 44 by 26.4 cm. The vertical forces produced by the foot or feet were channeled into four piezoelectric transducers where they were converted to electrical charges. Eight channels of a Kistler dual mode charge amplifier converted these charges to proportional voltages.

The signal from the charge amplifier was transmitted to an interface box by means of a cable with BNC female connectors on each end. Upon reaching the interface box, each channel was then directed to its proper pin placement in order to join the 25-pin male connector of the analog to digital (A to D) convertor. The signals were then transmitted to the computer (Apple Computer, Inc.) through the A to D card inside the computer, where they were converted from analog to digital data. (See Figure 6 for a schematic of data collection equipment.)

Because the balance beam needed to be solid, level, and exactly 44 cm in length, it was designed and built for use on the forceplate in this study. It was the same

height and width as the Bruininks-Oseretsky balance beam but was made of wood and did not slope from the balance area to the base.

Procedure

Orthoptic vision screening tests were conducted in order to eliminate potential subjects with depth perception problems. This procedure was deemed necessary so that static balance performance would not be confounded by poor depth perception.

Data collection took place at the Center for the Study of Human Performance at Texas Woman's University. Height and weight data were collected with a beam scale. The forceplate was calibrated prior to and following data collection by means of a computer program and known weights.

Metric graph paper was used to standardize foot or feet placement on the forceplate. Prior to data collection, each subject's bare foot or feet were centered and outlined relative to the center of the active area. For the two balance beam tests, the subject's foot was also centered on the balance beam. Measuring tapes were nailed to each side of the beam with 0 cm located in the exact center and 22 cm at either end; two movable pointers

aided in centering the subject's foot (See Figure 7).

Each subject was individually administered five static balance tests following test protocol. Tests were administered to odd-numbered subjects in sequential order and to even-numbered subjects in reverse order to facilitate administration by the trained examiners. Prior to data collection, each subject was allowed one practice trial.

After the subject achieved the criterion position for each static balance test, data collection was begun. Data were collected at a rate of 100 samples per second for 3 s or until balance was lost; the computer operator controlled when data collection began. Data were collected using two computer programs--COP COLL1 (Wilkerson & Folsom-Meek, 1986) for one-foot tests and COP COLL2 (Folsom-Meek & Wilkerson, 1986b) for the two-foot test. Data were recorded on computer disks for further analyses.

Analyses of Data

The Applesoft BASIC computer program, COP ANALYSES (Folsom-Meek & Wilkerson, 1986a) was written to compute mean center of pressure displacement for each subject with each static balance test. To determine the length of time

subjects balanced on the forceplate, tests of known time periods of balance were performed to determine the exact percentage of body weight that demonstrated loss-of-balance. This procedure allowed any slight unweighting due to balance adjustments made by the subjects without total loss of balance to the extent of leaving the forceplate. Time-in-balance was determined to be 90% or more of subject's body weight. Data files were then created on the DECsystem 2050 mainframe computer. Statistical programs using BMDP7D (Dixon, 1983) were written to calculate descriptive statistics for the two groups. The hypotheses for the study were tested by means of a BMDP3D multivariate _t_-test statistics program.

Results

Descriptive statistics computed on the data included the subject group means on the score determination (mean) of static balance performance (center of pressure fluctuation) and time-in-balance. For description of mean center of pressure fluctuations of static balance performance, there were similar means of individual means (score determinations) for both subject groups except for Standing on One Foot with Eyes Closed test (Table 1). For

this test, the mean of the nonhandicapped group was considerably higher than that of the learning disabled group, which denotes a greater amount of mean center of pressure fluctuation. The learning disabled group, however, demonstrated more variability than the nonhandicapped group.

Inspection of mean time-in-balance scores reveals that the nonhandicapped group exhibited longer time-in-balance scores than the learning disabled group (Table 2). Again, the learning disabled group demonstrated more variability than the nonhandicapped group.

Mean center of pressure displacement was the dependent variable for each of the group comparisons. The multivariate analysis indicated no overall significant difference between nonhandicapped and learning disabled subjects' static balance performance [$\underline{F}(5,33)=1.08$, $\underline{p}=.39$]. Because the result of the multivariate test was nonsignificant, a more stringent alpha level was calculated for the univariate analyses using the Bonferonni procedure. This was done to control against a Type I error because of multiple testing. In this procedure, the alpha level is divided by the number of

comparisons made (≅.05/5=.01), and probability levels are tested against these new alpha levels of .01. As a result of this procedure, there were no significant differences between the two groups on any of the five tests (Table 3). Therefore, each of the six hypotheses of no difference in static balance performance between nonhandicapped and learning disabled subject groups were accepted.

Discussion

The relationship between time-in-balance and mean deviation of the center of pressure in the medial-lateral direction may have confounded the results of this study. Because the nonhandicapped group balanced longer than the learning disabled group on all static balance tests, there was more time available to deviate from their initial starting positions on the forceplate. Although static balance is composed of compensatory movements, it might be better described as a function of both center of pressure deviations and time.

Protocol for the Bruininks-Oseretsky balance beam tests was modified for this study. Although it is stated in the Bruininks-Oseretsky Examiner's Manual (Bruininks,

1978) that subjects are to wear sneakers or crepe-soled shoes, subjects were barefooted to follow recommended protocol for the forceplate (Effgen, 1981; Harris, Knox, Larson, Sances, & Millar, 1982; Kelly, Redford, Silber, & Madden, 1981; Madden, 1979; Murray, Seireg, & Sepic, 1975). This modification might be reflected in the results of balance beam performance of the subjects in this study. Because shoes provide a more stable base of support than do bare feet, it appears that they would enhance balance performance.

The forceplate and its accompanying apparatus are highly sensitive to slight center of pressure fluctuations. In the present study, however, the forceplate data did not discriminate between the two subject groups when mean center of pressure deviations in the medial-lateral plane were analyzed. Two factors that were controlled in this study were orthoptic vision problems and examiner subjectivity. Because depth perception problems could confound results of static balance performance, potential subjects displaying them were not a part of the study. The trained examiners were not told which group the subjects represented; therefore they displayed the same attitudes toward the subjects when

administering the tests. Furthermore, results of balance performance were unknown to examiners because data were recorded on computer disks.

Because of the uniqueness of the present study in regard to equipment, methodology, and subject groups, the reader is advised to note the single direction of the study. Comparisons between the two groups with mean center of pressure deviation in the anterior-posterior plane, total area traversed, pathways of center of pressure deviation, and time-in-balance based on subject's weight on the forceplate would provide additional descriptions of static balance performance. Within the scope of this study, however, it may be concluded that nonhandicapped and learning disabled male children do not differ in static balance performance when mean medial-lateral center of pressure deviations from the initial starting positions on the forceplate are compared.

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Table 1

Description cf Subject Groups on Score Determination (Mean) of Static Balance Performance

Variable	Range (low - high)	*M*	*SD*	*SEM*
SPLB				
N	1.43 (0.14-1.57)	0.70	0.34	0.08
LD	0.82 (0.21-1.03)	0.61	0.22	0.05
SPLBEC				
N [a]	1.01 (0.32-1.33)	0.76	0.26	0.06
LD	1.57 (0.27-1.84)	0.74	0.42	0.09
SOT				
N	2.02 (0.30-2.32)	0.95	0.52	0.12
LD	2.68 (0.16-2.84)	0.91	0.60	0.13
SHTEC				
N	2.02 (0.17-2.19)	0.99	0.51	0.11
LD [a]	2.11 (0.26-2.37)	1.03	0.59	0.14
SOTEC				
N [a]	1.95 (0.45-2.40)	1.44	0.58	0.13
LD	2.77 (0.11-2.[illegible])	0.95	0.69	0.16

Note. Measurement units are expressed in centimeters.

[a]Data files were not available for one subject (*n* = 19).

Table 2

Time-in-Balance of Subject Groups

Variable	Range (low - high)	M	SD	SEM
SPLB				
N	2.57 (0.44 - 3.01)	2.55	0.83	0.19
LD	2.35 (0.66 - 3.01)	2.42	0.77	0.17
SPLBEC				
N [a]	2.43 (0.58 - 3.01)	1.90	0.82	0.19
LD	2.52 (0.49 - 3.01)	1.86	0.88	0.20
SOT				
N	0.40 (2.61 - 3.01)	2.99	0.09	0.02
LD	2.46 (0.55 - 3.01)	2.52	0.92	0.20
SHTEC				
N	0.91 (2.10 - 3.01)	2.96	0.20	0.05
LD [a]	1.94 (1.07 - 3.01)	2.78	0.52	0.12
SOTEC				
N [a]	1.54 (1.47 - 3.01)	2.60	0.59	0.14
LD	2.87 (0.14 - 3.01)	1.65	0.88	0.20

Note. Measurement units are expressed in seconds.
N = normal subject group (n = 20); LD = learning disabled subject group (n = 20).

[a]Data files were not available for one subject (n = 19).

Table 3

Univariate Comparisons of Mean Center o[illegible]ssure Deviation Between Normal and Learning Disabled Subjects on the Five Static Balance Tests

Variable[a]	Statistic	*t*	*df*	*p*
SPLB	*t*(separate)[b]	1.01	31.9	.32
SPLBEC	*t*(separate)	0.17	31.6	.86
SOT	*t*(pooled)[c]	0.21	38.0	.84
SHTEC	*t*(pooled)	- 0.24	37.0	.81
SOTEC	*t*(pooled)	2.38	37.0	.02

[a]The overall multivariate test results were:

Hotellings $T^2 = 6.07$

$F(5,33) = 1.08$, $p = .39$

[b]*t*(separate)--formula does not pool variances because Levene's test for homogeneity of variance indicated unequal variances for the groups.

[c]*t*(pooled)--formula calculated with a pooled variance because Levene's test for homogeneity of variance indicated homogeneous variances for the groups.

Figure 1. Standing on Preferred Leg on Balance Beam (SPLB) test position.

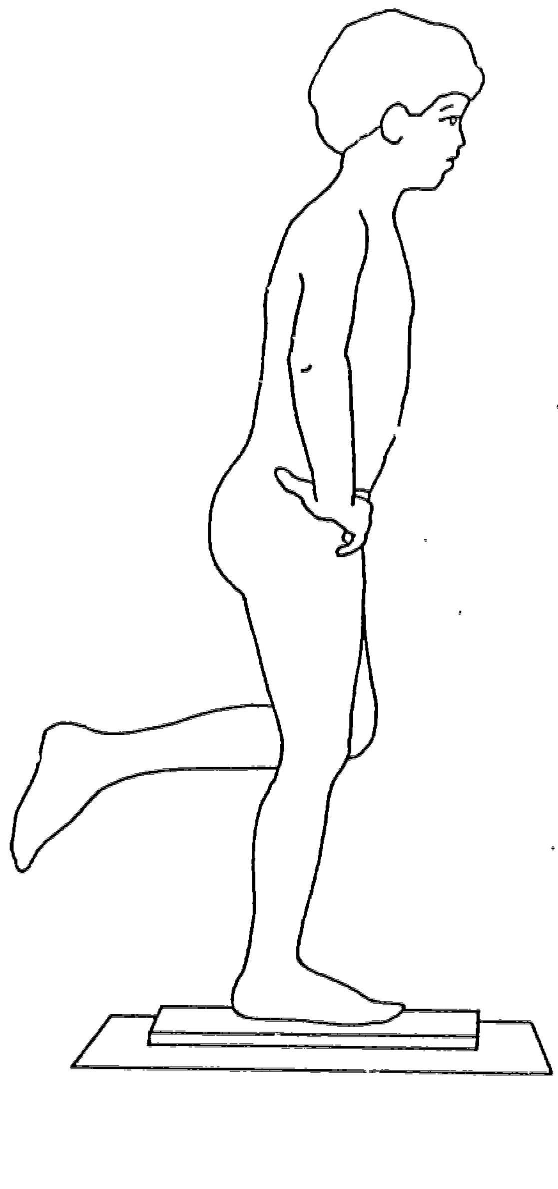

Figure 2. Standing on Preferred Leg on Balance Beam--Eyes Closed (SPLBEC) test position.

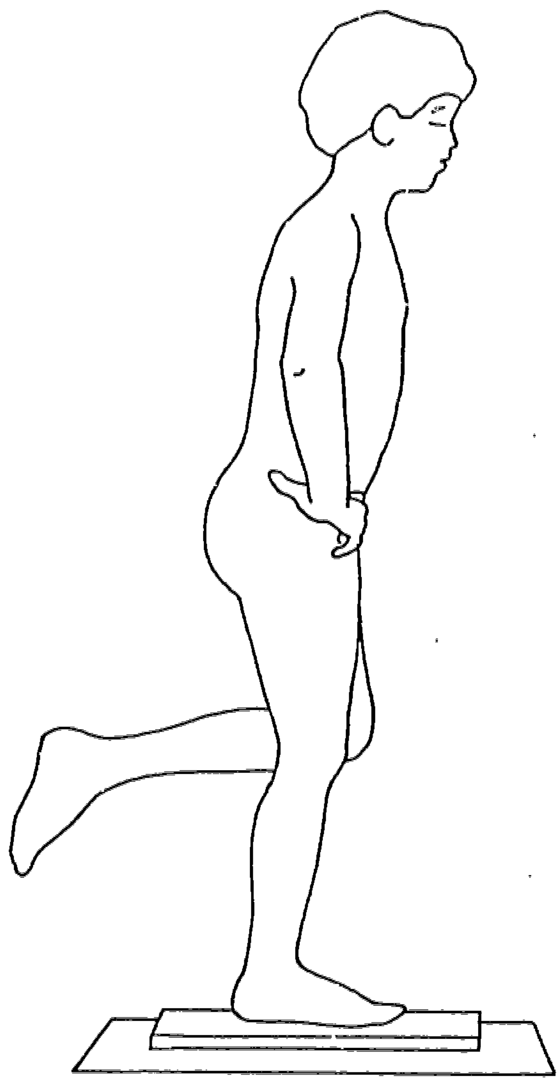

Figure 3. Standing on One Foot (SOT) test position.

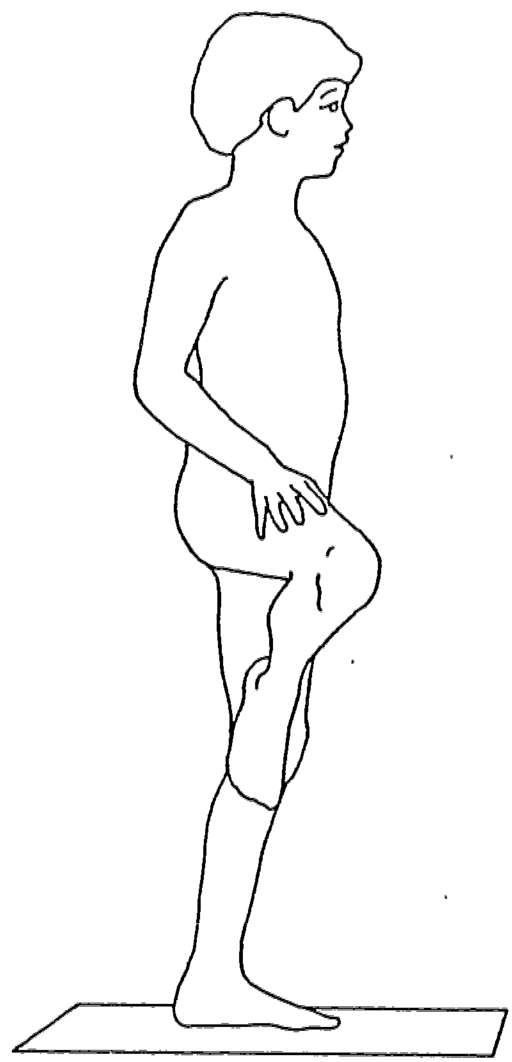

Figure 4. Standing Heel to Toe with Eyes Closed (SHTEC) test position.

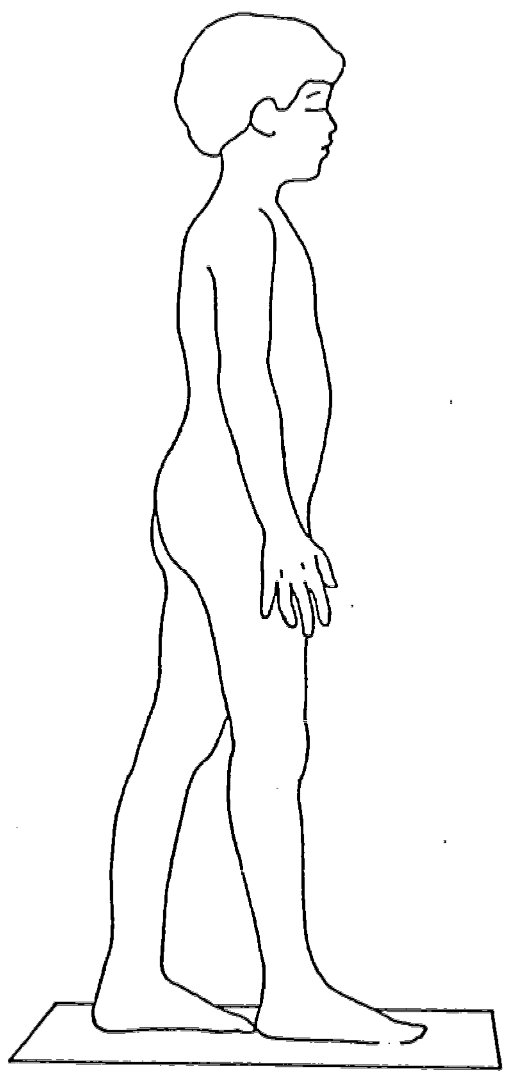

Figure 5. Standing on One Foot with Eyes Closed (SOTEC) test position.

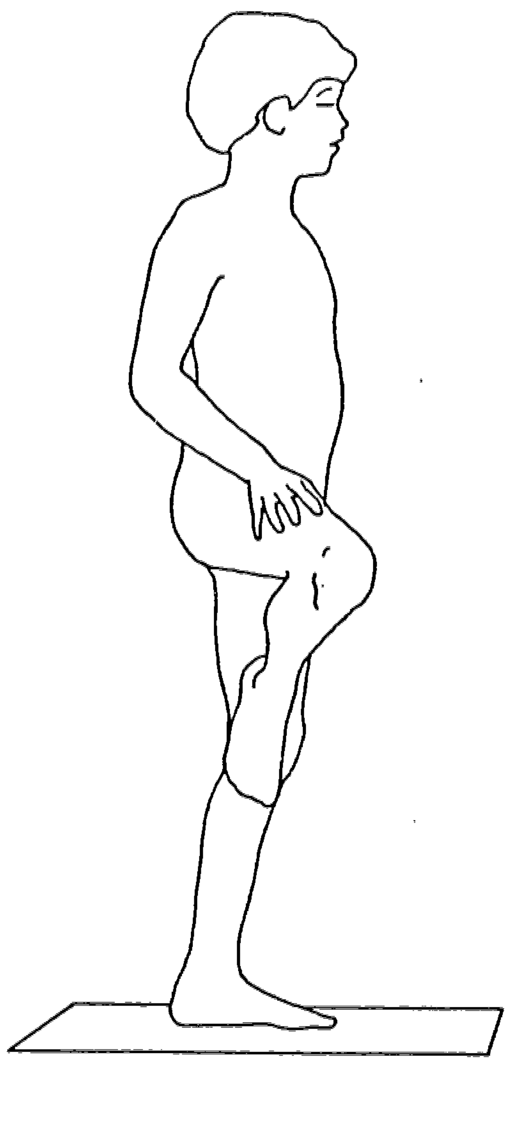

Figure 6. Schematic of forceplate data collection equipment.

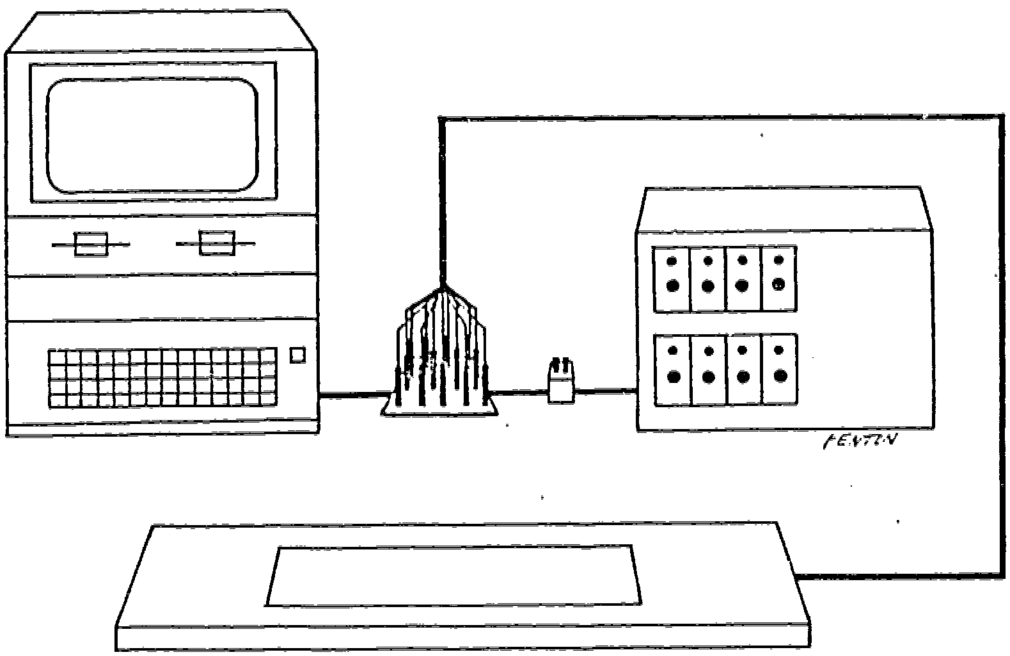

Figure 7. Balance beam for forceplate data collection.